SCIENCE:

A Weekly Record of Scientific Progress.

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THE ADVANCEMENT OF SCIENCE.

We cordially congratulate the managers of the American Association for the Advancement of Science, on the very thorough success which has attended its twenty-ninth annual meeting, held last week at Boston.

We have in this issue devoted nearly the whole of our space to chronicling its proceedings, and we draw special attention to the masterly address of the retiring President, Professor George F. Barker, which we present in full.

The address of welcome delivered by the venerable Professor William B. Rogers, L. L. D., will also be read with interest; he traces the history of the Association from its cradle, when it was called the Association of American Naturalists and Geologists, to its high position at this moment, when, as he hopefully said, it may be even fairly on its way to overtake the British Association, which has a roll of membership of 3,500 persons, and an income of $12,500, and at the same time 1,000 life members.

The success of the present meeting, and the addition of nearly six hundred new members, would seem to warrant the most brilliant anticipations for the future of the Association; and if its members follow the excellent advice of Professor Rogers, and do whatever is in their power to "quicken scientific thought, to accumulate scientific facts and investigate scientific laws," and generally to advance science, the result must elevate this Association to a position second to no other in the civilized world.

We are also reminded by Professor Rogers that while the chief function of the Association is to advance the progress of science; the term advancement necessarily implies diffusion, it would, therefore, appear an appropriate moment to speak of the value of this Journal in this connection. In addition to our report in this issue the addresses of Professor Hall, of Washington, and Professor Agassiz will be published in full. Of the two hundred and eighty papers read before the Association, some will be published by us *verbatim*, commencing next week with that of Mr. Alexander Graham Bell on his new instrument, the Photophone, illustrated with twelve drawings, placed at our disposal by Mr. Bell; and of the other papers, we hope to give extracts of the most important.

If, then, the advancement of science necessarily implies its diffusion, we may, with justice, claim for this journal some credit in the great work, as Professor Rogers said, in sowing the seeds of science as widely as possible through the world, waking up in all quarters those latent spirits, whose inborn talent and tendencies will hereafter blossom and fructify in scientific results.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The twenty-ninth meeting of this Association met at Boston, Mass., on the 25th of last month, under the presidency of Professor Lewis H. Morgan, of Rochester, N. Y.

Professor George F. Barker having called the meeting to order, and introduced the President elect, the proceedings commenced by an address of welcome from Professor William B. Rogers, L. L. D., President of the Massachusetts Institute of Technology. After a few preliminary remarks, Professor Rogers continued as follows:

The American Association for the Advancement of Science has never yet held a meeting in this city of Franklin, and I may say, also, the city of Bowditch, not to mention the long line of other scientific worthies, prominent among whom is our great instructor, our adopted citizen, Louis Agassiz. It seems a fitting place for such an association to convene. Its spirit, its institutions, its history, its habits and sympathies, all favor such a reunion between its citizens and the advocates and votaries of science. It was my good fortune, if it is a good fortune of any man to be able to date back his life for a long period of years, to have been familiar with the cradle of this institution in the form in which it first presented itself as the Association of American Naturalists and Geologists. This, however, was not by any means the earliest congress of science assembled in the world. The origination of this thought of a parliamentary annual meeting of scientific men seems properly to belong to a great German philosopher and speculator (?), who as early as 1822 organized the German Association for the Advancement of Science. For eight or nine years this example was not followed, but in 1831 Brewster, aided by Brougham, established the great British Association for the Advancement of Science, which we are to regard as the parent institution from which we have sprung. This British association, meeting in the ancient city of York in 1831, had its annual assemblings for a series of years in all the great capitals and some of the secondary cities in Great Britain. Faithfully administering to the needs and stimulating the energies of scientific inquiry, and publishing its annual solid quarto, which is a library representing the progress of physical and natural science of that time comparable to any that can be presented on the shelves of any collection of books in the world. Now this British association is holding to-day its fiftieth annual meeting; and now, in the afternoon of its assembling, I can imagine clearly in my mind's eye some of those great dignitaries of science that are there assembled. I can think of Sir Joseph Hooker, of Sir William Thomson, of Huxley, of Tyndal, of Balfour Stewart, and of all the great worthies that illustrate physical, mathematical and natural science for the last generation; and as I look back on the records preceding

the present year from the commencement of the association in Great Britain till this time, I find the chair of the presidency of that institution. as well as all the official characters connected with it, men who are or have been eminent for their promotion of scientific truths. I trust to-day before we shall have closed our assembling there will be transmitted by the cable a vote of greeting from the American Association of Science assembled here to the British association now assembled at Swansea.

Soon after this there came our American Association of Materialists and Geologists. I look around me and I think of the history of that active band of scientific workers, when all our State surveys were in their earlier states, when our geology, palcontology, our natural history in fact, in general was in a comparatively unexplored condition, and I feel saddened that I am the only member of the presidents of that early institution except one who has been, so far as intellectual laws are concerned, entirely removed from all association with scientific men. In the year 1847, during my presidency of this smaller institution, the plan was organized for a more extended and comprehensive form of social organization for the advancement of science; and in the year 1848, under the presidency of Mr. Redfield of New York, the first meeting of this enlarged association as it now exists was held in the city of Philadelphia. Since that time, consecutively year by year, this Association has assembled, save only during that dark period when, through most sad necessities, unfortunate circumstances and dreadful commissions, this association was compelled to hold its peace. But since 1865 the Association, with renewed vigor, has been prosecuting its work, and now we are assembled for the twenty-eighth time at an annual meeting to carry on this active labor of scientific instruction.

Now, what are the functions of such an Association? Its title tells. It is an association for the advancement of science, and it is expected and required of all those who become its members that they shall do whatever is in their power to quicken scientific thought, to accumulate scientific facts, to investigate scientific laws, or, in other words, to advance the progress of science throughout the world. But this term advancement necessarily implies diffusion, and while it is an association for the advancement of science it is no less an association for its diffusion, and this justifies in the highest degree the comparatively popular character of the meetings of the American Association. How can we best advance science but by sowing the seeds of science as widely as possible through the world, wakening up in all quarters where the association assembles those latent spirits, those unborn talents and tendencies which will hereafter blossom and fructify in scientific results. Thus it is, then, gentlemen, that we have our association assemblies here, and while I would not compare it as yet in point of numbers, in point of strength with the parent association in Great Britain, I see here to-day and hear from all quarters amongst those who are connected with the working operations of this meeting the enormous increase which is promised this association in its future growth. Let us think for a moment. For the last twenty years the British Association has had an average number on its rolls of members of all classes of 3,500; it has had an average attendance of nearly 2,500; it has had an average income from its members of $12,500, having at the same time 1,000 life members, and being able, practically and actively, to promote scientific research by the bestowal of grants for different departments of inquiry of a sum amounting of from $5,000 to $10,000 a year. Now, gentlemen of the Association and citizens of Boston, here is something for us to emulate. Here is a direction of progress in which we can be sustained by the strong and hearty approval, nay, the applause, of all scholarly and scientific men throughout the world. And, from what I have learned to-day, I do not doubt that the American Association of Science is fairly in the way to overtake the great association which is now assembled at Swansea, in regard to its numbers and its resources. And, as to the character of the works that are presented, of course in all such exercises the materials that are gathered together are of various qualities as well as shapes and dimensions. Let us now make it our special work to exclude from our annual reports all detailed publications which are not of a character actually to add to the stock of human knowledge, whether that knowledge be simply the gathering together of facts by careful processes of discernment, or the development of laws by careful mathematical investigation And, therefore, let it be our work, as I trust it will be, and has been already, in fact, suggested by our secretary, that these prolonged discussions, which, however valuable in the main they may be or not of the quality and character to belong to the transactions of a great body like this, shall be presented in small type and in abstract in the latter part of the volume.

I thank my friends for the patience with which they have listened to one who does not like to call himself an old man, but who still finds something of the sentiment of the war-worn soldier who likes always, if he have a kindly audience, to shoulder his crutch and fight his battles o'er again. [Applause.] If I have taken too much of your time I beg your pardon. As I have spoken in behalf of this committee of the city of Boston, let me conclude with my personal welcome in behalf of this institution, over which I have the honor to preside, and to say to you that the corporation and officers of the Institute of Technology are not only glad but they are proud to welcome the American Association for the Advancement of Science into this hall and to all the accommodations and comforts which it can offer.

The Mayor of Boston, the Hon. Frederick O. Prince, then addressed a few words of welcome, and was followed by His Excellency Governor Long, who delivered an additional address for the same purpose.

The response of President Morgan, on behalf of the Association, was as follows:

MR. CHAIRMAN:—The Association has listened with much pleasure to your address of welcome to the city of Boston. In no other city of our land are better appreciated the unity of the sciences and the brotherhood of scientific men. These are central ideas of this Association, and when we meet among a people whose hospitality is vitalized by intelligent sympathy, a powerful impulse is given to the work which it was designed to promote. I venture to predict, sir, that this meeting will become memorable in our history. It may seem singular that this session of the Association should be the first one held in the good city of Boston, during the long series of twenty-nine annual meetings. It has, however, met at Cambridge, which in the public eye is a part of Boston. We cannot and we ought not to separate Cambridge, with its noble university and its distinguished body of teachers, from Boston, in which the roots of Cambridge are planted. They are "one and inseparable" in association as in fame. Thus we are enabled to say that this Association is indebted to Boston for a peerless cluster of presidents: The illustrious and lamented Agassiz, to whom American science is so deeply indebted; the learned and gentle Wyman, whose loss we still mourn; these have ceased from among us, and their departure has rounded and completed their fame. Rogers, Peirce, Gould, Gray, Lovering yet remain with us, and, therefore, we cannot on this occasion speak of them as their distinction deserves. "*Seri in cœlum redeatis*."

Mr. Mayor:—The American Association for the Advancement of Science is popular in its character, as it should be. Investigators in all departments of science are cordially welcomed to its membership. By this free intercourse of persons engaged in scientific pursuits, results of the highest importance are constantly attained. When the meetings of this Association become indifferent to the communities among which they are held, its usefulness will be near its end. There is a direct connection between the work upon which its members are engaged and the material prosperity of the country, in which all alike have an interest. Scientific investigations ascertain and establish principles which inventive genius then utilizes for the common benefit. We cannot have a great nation without a great development of the industrial arts, and this, in its turn, depends upon the results of scientific discovery as necessary antecedents. Material development, therefore, is intimately related to progress in science.

Your Excellency, Governor of the Commonwealth of Massachusetts:—Without intending to depart from the proprieties of the occasion, it may be proper to say, that

those of us who come from beyond the Hudson can but feel that in entering New England we reach the birthplace of American institutions. To some of us it is the land of our fathers, and we cannot approach the precincts of their departed presence without the sentiment of filial veneration. Here they laid, broad and deep, the foundations of American freedom, without which American science would have been an infant in leading strings to-day.

Mr. Chairman and Gentlemen:—With a grateful appreciation of the kindness of the people of Boston, the Association is now prepared to enter upon the regular work of the session.

GENERAL BUSINESS.

The association then proceeded to routine business. The permanent secretary gave notice that the following members of the assocation had died since the last meeting, viz.:

George W. Abbe, of New York, died September 25, 1879.
E. B. Andrews, Lancaster, Ohio.
Homer C. Blake, New York.
F. A. Cairns, New York.
Caleb Cook, Salem, Mass., died June 5, 1880.
Benjamin F. Mudge, Manhattan, Kansas, died November 21, 1879.
Thomas Nicholson, New Orleans, La.
Louis François de Pourtales, Cambridge, Mass., died July 18, 1880.

The financial report, presented by the secretary, showed for the first time since he has been in office a balance in favor of the sssociation. The total receipts during the year were $5430.35, principally from assessments and entrance fees. The disbursements were: Expenses of the Saratoga meeting, $189.82; publication of 1250 copies of proceedings of Saratoga meeting, $2142.64; salaries of permanent and assistanf secretaries, $1396. The balance in hand was $148.-24. The life membership fund amounted to $975.77.

The standing committee was then completed, and includes, besides the officers of the association, the following fellows: N. T. Lupton, F. W. Clarke, E. T. Cox, W. Harkness, O. T. Mason and S. A. Lattimore.

On motion from the floor, a standing committee was appointed by the president to prepare a message of greeting to the British Association, to be sent by cable. Professor W. B. Rogers, Asa Gray and N. T. Lapton were appointed, and sent the following despatch: "The American Association for the Advancement of Science, in session in Boston, sends cordial greetings to the British Association at Swansea, on the occasion of its fiftieth meeting."

The president was requested to appoint a committee of three to propose suitable resolutions of regret at the death of the late General Albert J. Moyer, of the United States Signal Service.

Over four hundred ladies and gentlemen were elected members of the association.

It was voted that, with the exception of Thursday, the morning session begin at ten o'clock and close at one o'clock; and that the afternoon session begin at 2:30 o'clock and close at five o'clock. The general session then adjourned.

The Sections then organized. Section A was called to order in Huntington Hall. Professors A. W. Wright, A. M. Mayer and John Trowbridge were elected the committee to coöperate with the Vice President and Secretary of the Section, and the Chairmen and Secretaries of the Sub-Sections. F. H. Smith, A. E. Dolbear, J. M. Van Vleck and Thomas Hill were chosen on the nominating committee, which acts with the standing committee in the selection of officers for next year. The Section then adjourned. Alexander Agassiz presided at the meeting of Section B. G. L. Goodale, E. D. Cope and B. G. Wilder were chosen the sectional committee, and C. S. Minot, A. J. Cook, W. G. Farlow and Thomas Mahon, nominating committee. On motion of Dr. Minot, it was voted to form a Permanent Section of Biology. The Section then adjourned to Friday. In the afternoon Mr. Asaph Hall gave the Vice President's address of Section A at half-past two; Professor J. M. Ordway read the Chairman's address to the Sub-Section of Chemistry at four; at the same time Major J. W. Powell pronounced the Chairman's address before the Anthropological Section, while the official address in microscopy was admitted. The Entomological Club met at five o'clock, Mr. A. R. Grote in the chair. A communication from W. H. Edwards was presented; Mr. McCook concluded his comment on the honey ant; Mr. A. J. Cook offered some comment; Mr. E. P. Austin exhibited plates; an essay from S. A. Forbes was read, and Dr. G. F. Waters discussed it. In the evening the retiring President pronounced his great oration on life as a problem of chemistry and physics.

THURSDAY, AUGUST 27TH.

The second day of the meeting was spent by the American Association in Cambridge. At eleven o'clock an audience of nine hundred assembled in the Sanders Theatre to listen to the eulogy by Professor Alfred M. Mayer upon the late Joseph Henry, and to the annual address by Professor A. Agassiz before the natural history section. The audience included nearly all the members of the Association registered this year, with the addition of a large number from Cambridge. The Harvard professors are usually absent during the summer vacation, but on this occasion nearly the entire scientific faculty were present to receive and honor their friends and guests. At the short business meeting of the general session twenty new members were admitted to the Association, and the following resolution, offered by Dr. L. C. Le Conte, referred to a standing committee: "Resolved, that the constitution and by-laws be so amended as to establish a Section C of biology, with an organization similar to that of the two existing sections." After the addresses at the theatre dinner was served in Memorial hall, Mr. Martin Brimmer presiding, but made no remarks and gave no toasts. After dinner the ladies and gentlemen visited the scientific collections, especially the two museums, the mineralogical cabinet, the physical laboratory, the library and the historic points of Cambridge. At four o'clock the visitors gathered in about equal numbers at the botanic garden, the observatory and the house of Mrs. T. P. James. At the garden Professor Asa Gray spoke on the characteristics and distribution of the Rocky Mountain vegetation. Professor E. C. Pickering, the director, offered an opportunity for inspecting the observatory, while Mrs. James entertained those interested in keramics. In the evening there was a reception at Mr. and Mrs. A. Graham Bell's residence.

FRIDAY, AUGUST 28TH.

Little routine was required to be transacted, and the sections and sub-sections settled down to steady work. It was announced that so far nine hundred ladies and gentlemen had entered their names for membership, and that the attendance was a hundred-fold more than was usually present on former occasions.

Among the more important papers read were:

"Determination of the routine time of Jupiter, from observations of the red spot in 1879-80; together with the physical character and changes of the spot," by H. S. Pritchett.

"Determination of the comparative dimensions of the ultimate molecules, and deduction of the specific properties of substances," W. N. Norton.

"Friction of lubricating oils," C. J. Woodbury.

"Steady and vortex motions in vis-cous incompressible fluids," Thomas Craig.

"Spectroscopic notes," C. A. Young.

"Discussion of the phenomena observed in comparing the spectrum of the light from the limbs with that from the centre of the solar disk," C. S. Hastings.

"Maxima and minima tide predicting machine," W. Ferrel.

"Methods in use at the Observatory at Yale for the verification of thermometers and testing of time pieces," Leonard Waldo.

"Heat produced by magnetizing and demagnetizing iron and steel," John Trowbridge.

"Lecture experiments for the direct determination of the velocity of sound," W. A. Anthony.

"On the refractive index of metallic silver," Arthur W. Wright.

"On a form of vacuum tube for spectroscopic works," Arthur W. Wright.

"Progress made at the Observatory of Harvard College in the determination of the absolute coördinates of 109 fundumental stars;" "A simple and expeditious method of investigating all the division errors of a meridian circle;" "The systematic errors of the Greenwich right ascensions of southern stars observed between 1816 and 1831; "Preliminany determination of the equation between the British imperial standard yard and the metre of the archives;" "The probable error of a single observation at sea,

deduced from the observations of W. H. Bacon, Cunard steamer Scythia," all by W. A. Rogers.

CHEMISTRY.

Rotary power of glucose and grape sugar—H. W. Wiley.
Actinism—A. R. Leeds.
The occurrence of oxide of antimony in extensive lodes in Senora—Mexico.
Convenient scale and apparatus in gas analysis—E. W. Morley.
On the constitution of tartrates of antimony—F. W. Clarke.
Action of sunlight on glass—Thomas Gaffield.
Near ratio of oxygen to nitrogen in the atmosphere—E. W. Morley.

SUBSECTION MICROSCOPY.

"Microscopic studies in Central Florida," C. C. Merriam; "The errors of a few English, French and American stage micrometers," William A. Rogers; "Apparatus used in photographing microscopical objects," Samuel Wells; "A new freezing microtome," William Hailes; "Microscopical investigations of the Havana yellow fever," George M. Sternberg; "Permanent microscopic preparations of Amphibian blood corpuscles," S. H. Gage; "Permanent microscopic preparations of Plasmodium," S. H. Gage.

BIOLOGY.

"Comparative anatomy as a part of the medical curriculum," Harrison Allen; "Distinguishing species of Populus and Juglans by the young naked branches," W. J. Beal; "Observations on Japanese Brachiopoda," E. S. Morse; "An investigation of the peach yellows," B. D. Halsted; "Incomplete adaptation as illustrated by the history of sex in plants," L. F. Ward; "Evolution of parasitic plants," Thomas Meehan; "Anthrax of fruit trees, or the so-called fire-blight of the pear and twig-blight of the apple tree," T. J. Burrill; "Further notes on the pollination of Yucca, and on Pronuba and Prodoxus," C. V. Riley; "Fossil Dinocerata in the E. M. Museum at Princeton, N. J.," F. C. Hill; "Origin and Succession of Felidæ," E. D. Cope; "Preservation of fossil insects and plants at Malon Creek," J. W. Pike; "Menobranchus lateralis," P. R. Hoy.

GEOLOGY.

Before the geologists were presented ten essays: "The Cupriferous series in Minnesota," N. H. Winchell; "The excavation of the upper basin and clove of the Kaaterskill, Catskill Mountains, N. Y.," Alexis A. Julian; "Progress of geological investigation in New Brunswick, 1870–1880," L. W. Bailey; "The tertiary age of the iron ores of the lower silurian limestone valleys," H. C. Lewis; "Note on the Turquoise localities of Los Cerillos," B. Silliman; "Los Cerillos, New Mexico, an area of recent eruptive rocks with mineral veins," B. Silliman; "Iron mines of Ore Hill, Conn., and vicinity, and the making of pig iron," W. A. Stearns; "Law of land forming on our globe," Richard Owen; "Kames and eskors in Maine," George H. Stone; "Occurrence of tin ore at Winslow, Me.," C. H. Hitchcock.

ANTHROPOLOGY.

The anthropologists met to listen to the following essays: "Ethnology of Africa, illustrated by a large manuscript map," A. S. Bickmore; "Myths and folk lore of the Iroquois," Erminnie A. Smith; "Prehistoric altars of Whiteside county, Illinois," W. C. Holbrook; "Theory of primitive democracy in the Alps," D. W. Ross; "Ancient mounds in the vicinity of Naples, Illinois, Pt. II. Illustrated with skulls, pipes, copper axes, bone implements and other articles from the mounds," J. G. Henderson; "The mounds of Illinois," William McAdams; "Prehistoric and early types of Japanese pottery," E. S. Morse.

In the evening Mr. Alexander Graham Bell brought before the Association his recent discovery of the Photophone, and researches with Mr. Sumner Tainter in the production and reproduction of sound by means of light.

SATURDAY, AUGUST 28TH.

In general session a few new members were elected, and on motion of Professor Ormond Stone, the standing committee of the Association was instructed to refer the subject of standard time to a special committee. In section A a sub-section H of mathematics and astronomy was organized with Mr. Simon Newcomb, of Washington, as chairman, and Mr. Winslow Upton, of Washington, as Secretary.

The following papers were also read in the various sections and bi-sections.

PHYSICS.

"On the present condition of musical pitch in Boston and vicinity," Charles R. Cross and William T. Miller; "The Co-efficient of expansion of gas solutions," from the Messrs. E. L. Nichols and A. W. Wheeler, and "The new action of magnetism on a permanent electric current," by Mr. E. H. Hall; the latter being among the most important papers, theoretically considered, ever contributed by an American to the science of physics. Then came "A simple device for projecting vibrations of a liquid film without a lens," by H. S. Carhart; "Observations on some recent hailstorms in North Carolina," by J. R. Blake; and "Results of a magnetic survey of Missouri," by Francis E. Nipher.

MATHEMATICS AND ASTRONOMY.

"The solar parallax for meridian observation of Mars in 1877," by J. R. Eastman; "A note on zodiacal light," by H. C. Lewis, and a "Tidal theory of the forms of comets."

CHEMISTRY.

"On a solution of ferric gallate and ferric oxalate as a reagent for quantitive analysis of ammonia," N. B. Webster.
"Description of new substituted acrylic acids," C. F. Malberry.
"The valuation of indigo," L. M. Norton.
"The soil supply of nitrogen for plants," W. O. Atwater.
"Incrustations formed in pipes used in gas wells," H. L. Nason.
"A modification of Bertier's process for the valuation of coal," Charles E. Monroe.
"Observation on the temperature and chemical character of Mystic Lake, Mass," W. R. Nichols.

MICROSCOPY.

"On the limits of visibility with the microscope," A. E. Dolhear.
"Minute anatomy of the human Larnyx," Carl Seiler.
"Infusoria found in fresh ponds," S. P. Sharples.

NATURAL HISTORY.

"Endo-cranium and the maxillary suspensorium of the bee," G. Macloskie.
"Tongue in snakes and birds," C. S. Minot.
The age of the copper bearing rocks of Lake Superior, M. E. Wadsworth.
Structure and nomenclature of the brain, with special reference to that of the cat, Burt. G. Wilder (three papers).
Plan of the cerebro-spinal nervous system, S. V. Clevenger.

ANTHROPOLOGY.

Aboriginal pottery and stone implements, S. S. Holdeman.
Rude argillite implements, C. C. Abbott.
The Dacotah tribes, H. B. Carrujton.
Discoveries in the Mammoth, Wyandot and Luray caves, H. C. Hovey.

We propose to offer the readers of SCIENCE verbatim reports of the principal addresses, and lengthy abstracts of the leading papers, read before this important meeting of the Association, and will commence the series with that of the

ADDRESS OF PROFESSOR GEORGE F. BARKER, THE RETIRING PRESIDENT OF THE ASSOCIATION.

SOME MODERN ASPECTS OF THE LIFE QUESTION.

The number of roots in our equation of life increases the difficulty of solving it, but by no means permits the acceptance of the lazy assumption that it is altogether insoluble or reduces a sagacious guess to the level of the prophecy of a quack.—HAUGHTON.

LADIES AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The discovery of new truth is the grand object of scientific work. The exultation of feeling which comes from the possession of a fact, which, now, for the first time, he makes known to men, must ever be the reward of the scientific worker. As investigators and as students of science we are met here to-day at this our annnual session. Each of us during the past year has been endeavoring to push outward further into the unknown, the boundary of present knowledge. When, therefore, we thus meet together it is fitting that, from time to time, our attention should be called to the progress which has been made along some one of the various lines of research, and to the milestones which mark the epoch of advance along the way which science has traveled. Moreover, we may profitably sum up at such times the work done in particular directions, and encourage ourselves with prospective and retrospective glances. In these summings up, however, a difficulty arises. The range of modern scientific thought includes an immense area. The field of knowledge is already so vast, that, seen from the vertical distance necessary to make a wide survey, that small portion of it which is familiar to any one individual is scarcely visible. In consequence, to use a mechanical figure, the solid contents of a man's acquirements being given, the depth thereof is inversely as the area covered. He, therefore, who undertakes to speak even for one single department of science distributes his stock of knowledge

over so broad a surface that in places it must be dangerously thin. It is, therefore, with a very keen sense of the temerity involved in the undertaking, that I ask your attention during the hour allotted me, to some points which appear to me to have been recently gained in the discussion of the question of life.

My friend and predecessor, Professor Marsh, opened his excellent address at Saratoga with the question "What is Life?" In a somewhat different sense I too ask the same question. But I fear it is only to echo his reply, "the answer is not yet." The result, however, cannot long be doubtful. "A thousand earnest seekers after truth seem to be slowly approaching a solution." And though the *ignis fatuus* of life still dances over the bogs of our misty knowledge, yet its true character cannot finally elude our investigation. The progress already made has hemmed it in on every side; and the province within which exclusively vital acts are now performed, narrows with each year of scientific research.

What now are we to understand by the word "Life" in this discussion? A noteworthy parallel is disclosed in the progress of human knowledge between the ideas of life and of force. Both conceptions have advanced, though not with equal rapidity, from a stage of complete separability from matter to one of complete inseparability. Life is now universally regarded as a phenomenon of matter, and hence of course, as having no separate existence. But there still exists a certain vagueness in the meaning of the term "life." Two distinct senses of this word are in use; the one metaphysical, the other physiological. The former, synonomous with mind and soul, at least in the higher animals, has been evolved from human consciousness; the latter has arisen from a more or less careful investigation of the phenomena of living beings. It need scarcely be said that it is in the sense last mentioned that the word "life" is used in science. The conception represents simply the sum of the phenomena exhibited by a living being.

Moreover, the progress which has been made in the solution of the life-question has been gained chiefly by investigation of special functions. But the functions of a vital organism are themselves vital. What then is the meaning of "vital" as applied to a function? Fortunately the answer is not difficult. "Life," says Küss, the distinguished Strasbourg physiologist, "is all that cannot be explained by chemistry or physics." Guided by such a definition the work of the physiological investigator is simple. He has only to test each separate operation which he finds going on in the organism and to declare whether it be chemical or physical. If it be either, then since each function is non-vital, the entire organism must be non-vital also. Hundreds of able investigators, provided with the most effective appliances of research, are now in full cry after the life principle. Naturally, a vast amount of collateral knowledge is accumulated in the process. The quantitative as well as the qualitative relations of things are fixed, and many important facts are collected.

With the object in view thus clearly defined, we are not surprised that great progress has been made. A vital process, like the catalytic ones of the older chemistry, was found by such research to be simply a process which, for want of sufficient investigation, is not yet understood. While therefore, undoubtedly, much work yet remains to be done in the realm still called vital, the prophetic vision is already bright which will witness the last traces of inexplicable phenomena vanish and the words expressing them relegated to the limbo of the obsolete.

As a first result of recent work, the living organism has been brought absolutely within the action of the law of the Conservation of Energy. Whether it be plant or animal, the whole of its energy must come from without itself being either absorbed directly or stored up in the food. An animal, like a machine, only transforms its energy. Lavoisier's guinea-pig, placed in the calorimeter, gave as accurate a heat-return for the energy it had absorbed in its food, as any thermic engine would have done. But the parallel goes further. The mechanical work of an engine is measured by the loss of its heat and not of its substance. So the mechanical or intellectual work of a living being is measured by the amount of food rather than the amount of tissue which is burned. The energy evolved daily by the human body would raise it to a height of about six miles.

But beside heat, work may be the out come of the organism; and this through the agency of the muscles. Their absolute obedience to mechanical law in their mode of action has been admirably established by Haughton. The work a muscle does, it does in contracting. It is to the mechanism of muscle-contraction that we are indebted for another illustration of our subject.

When work is done by a muscle in contracting, three changes are observed to take place in its tissue. First, there is a loss of its electric tension; second, there is an evolution of heat in it; and third, carbon dioxide appears there, and its reaction, before neutral, becomes acid.

Matteucci was the first to observe and to call attention to the remarkable similarity in structure and in the mechanism of operation, between striated muscular fibre and the electric organ of certain fishes. Recently, Marey has repeated and extended his observations. In structure, the electric organ is made up, like the muscle, of columnar masses each separable transversely into vesicular sections. In a torpedo weighing seventy-three pounds, there were 1182 of these columns, with 150 sections, on an average, in each, In the muscles which bend the fore-arm, there are 798,000 fibrillæ. As to the mechanism, alike in muscle and in electric organ, an electric current stimulates action on opening and on closing the circuit, but not when it is flowing; the same phenomena takes place in both with the direct and with the inverse current; both are reflex; stimulation of the electric nerve produces discharge, as that of the motor nerve causes muscular shock; an entire paralysis follows nerve-section; curare paralyzes both; and tetanus results in both from rapid currents or from strychnine.

Still more striking analogies are furnished by the investigation of the susurrus or muscular sound, first noticed in 1809 by Wollaston. This sound is produced by all muscles when in the state of contraction, the pitch of the note being not far from thirty vibrations per second. It is evidently only the intermittent discharge of the muscular fibre. A single excitation produces a muscular shock. As this production requires from eight to ten hundredths of a second, it is evident that if another stimulus be applied before the first has disappeared the two will coalesce; and when twenty per second reach the muscle it becomes permanently contracted or tetanized. By means of a very sensitive myograph, Marey has found that in voluntary contraction the motor nerves are the seats of successive acts, each of which produces an excitation of the muscle. In 1877, Marey examined similarly the discharge of the torpedo and found a most complete correspondence between it and muscular contraction. Since electric tension disappears from a muscle during contraction, is not the evidence conclusive that muscular contraction, like the discharge of the electric organ of the torpedo, is an electrical phenomenon?

Granting electric discharges to be the cause of muscle-contraction, what is its origin? That it is not carried to the muscle by the nerves follows from the fact that a muscle will still contract when deprived of all its nerve-fibres. It must therefore be generated within the muscle itself. To reach a solution of the problem we must obviously follow the analogies of its production elsewhere.

Perhaps no single question in physics has been more keenly discussed than this one of the origin of electric charge. The memorable conflict between Galvani and Volta, between animal electricity and the electricity of metallic contact, succeeded by the even more triumphant overthrow of the latter and the establishment ultimately by Faraday, of the electrochemical theory; these are facts fresh in all our memories. The justice of time however in this case, if it has been tardy, has been none the less sure. The experiments of Thomson have vindicated Volta and established the contact theory as a *vera causa*. And more curiously still, it now appears to be proved that both contact and chemical action underlie the production of that very animal electricity so stoutly battled for by Galvani and his associates.

Volta's experiments to prove that a difference of potential is developed by the contact of two heterogeneous metals were not crucial. But Thomson, repeating them with the aid of more delicate apparatus, has shown that whenever copper and zinc are brought in contact, the copper becomes negative to the zinc. In proof that the chemical action of atmospheric moisture was not the cause of the phenomenon,

he showed that when a drop of water served to connect the copper and the zinc, no charge at all was produced. The fact may therefore be regarded as established, as the result of numerous and varied experiments, that a difference of electrical potential is always developed at the surfaces of contact of heterogeneous media. Not only is this true of solids in contact with solids, but also of solids with liquids, and of liquids in contact with each other. Of course the production of electricity by contact must result from a loss of energy elsewhere. In the opinion of Cumming, it is the loss of energy which is owing to the unsymmetrical swinging of the molecules on the two sides of the surfaces of contact, which reappears as difference of potential between the solids or as the energy of electrical separation.

But we may carry the sequence yet another step backward. The energy which is thus lost at the surfaces of separation must be heat, and this junction must be cooled thereby. Thus the production of thermo-electricity is seen only to be a special case of a general law, a view to which the well-known Peltier effect gives support. In this phenomenon, when two metals are joined together in the form of a ring and one junction is heated, a current is produced which cools the other junction. From a study of these conditions, Thomson has concluded that the absorption of heat in a thermo-electric circuit varies for different metals with the direction of the current. Thus in iron, the current from hot to cold absorbs heat, while in copper the current which absorbs heat is from cold to hot. In entire accordance with these results, are the conclusions recently reached by Hoorweg. Whenever two conductors come into contact, motion of heat results in the development of electricity, the current produced existing at the cost of heat at one part of the point of contact, and evolving heat at the other for a result. Hence all voltaic currents are thermo-currents.

To return to the muscle, it must now be apparent that the electrical charge which appears in its fibre may have its origin in so purely a physical cause as the contact of the heterogeneous substances of which the tissue is built up; the maintenance of this charge being effected by chemical changes going on constantly in the substance of the muscle, by which the carbon dioxide is produced, which is shown to be a measure of the work done.

Conceding now, that muscular contraction is of the nature of an electric discharge, by what mechanism is the contraction effected? A string of electrical masses, like a muscular fibril, would seem at first to oppose the view now advauced. Such a row of particles would indeed attract each other when electrified, and shorten the length of the whole. But the force of contraction would increase as the length diminished; whereas the fact in the case of the muscle is precisely the reverse. Two theories have been advanced to account for the result. The first, proposed by Marey, likens the muscular fibre to a string of india-rubber which, when stretched, contracts upon the application of heat, thus transforming heat directly into work. The other, brought forward and strongly supported by Radcliffe, explains contraction by direct electric charge. Each fibre of the muscle, together with its sheath, constitutes a veritable condenser, the charge upon the exterior being positive, and upon the interior negative. When a charge is communicated to the fibre, lateral compression results from the attraction of the electricities of opposite name, and since the volume remains constant, elongation is the consequence—precisely as a band of caoutchouc, having strips of tin-foil upon its sides, may be shown to elongate when charged like a condenser. In this view of the matter the normal condition of the muscle is one of charge, of elongation. Contraction results from the simple elasticity of the muscle itself, the function of the nerve being only that of a discharger. Whether this theory represents the actual fact or not, in all its details, it is supported by the existence of *rigor mortis*, by the continued relaxation of muscle during the flow of the current, by the cessation of contraction on the free access of blood, and by many other phenomena otherwise difficult to explain.

From this brief review, does it not seem probable that the phenomenon of muscular contraction may be satisfactorily accounted for without the assumption of "vital irritability," so long invoked? May it not be conceded that the theory that muscular force has a purely physical origin is at least as probable as the vital theory?

Time would fail me to discuss the many other phenomena of the living body which have been found, on investigation, to be non-vital. Digestion, which Prout said it was impossible to believe was chemical, is now known to take place as well without the body as within it, and to result from non-vital ferments. Absorption is osmotic, and its selective power resides in the structure of the membrane and the diffusibility of the solution. Respiration is a purely chemical function. Oxyhæmoglobin is formed wherever hæmoglobin and oxygen come in contact, and the carbon dioxide of the serum exchanges with the oxygen of the air according to the law of gaseous diffusion. Circulation is the result of muscular effort both in the heart and the capillaries, and the flow which takes place is a simple hydraulic operation. Even coagulation, so tenaciously regarded as a vital process, has been shown to be purely chemical, whether we adopt the hypothesis of Schmidt that it results from the union of two proteids, fibrinogen and fibrinoplastic substance, or the later theory of Hammarsten that fibrin is produced from fibrinogen by the action of a special ferment.

One function yet remains which cannot be altogether omitted from our consideration. This function is that of the nervous system. In structure, this system is well known to us all. In composition, it is made up essentially of a single substance, discovered by Liebreich and called protagon, the specific characters of which have lately been confirmed by Gamgee. In function, the nerve-cell and the nerve-fibre are occupied solely in the reception and the transmission of energy, which is in all probability electrical. There is evidently a close analogy between the nerve and the muscle, the axis cylinder like the fibrilla being composed of cells, and having a positive electric charge upon the exterior surface, which has a tension of one-tenth of a volt. Haughton attributes *tinnitus aurium* to the discharge of nerve-cells.

The only objection raised to the electrical character of nerve-energy is based upon its slow propagation. Though thirty years ago Johannes Müller predicted that the velocity of nerve-transmission never could be measured, yet Helmholtz accomplished the feat very soon afterward. His results, like those of subsequent experimenters, show that the velocity of propagation of the nervous influence along a nerve, like that of electric transmission, is only about 26 to 29 metres in a second. But it should be borne in mind, as Lovering has pointed out, that electricity has no velocity, in any proper sense. That since the appearance of an electrical disturbance at the end of a conductor depends upon the production of a charge, the time of this appearance will be a joint function of the electrostatic capacity of the conductor and of its resistance. Since each of these values is directly proportional to length, it follows that the time of transmission will vary as the square of the length of the conductor. While therefore, in Wheatstone's experiment, he found that electricity required rather more than one-millionth of a second to pass through one-quarter of a mile of wire, it does not follow that it would traverse 288,000 miles in one second, as he assumed. Indeed, as Lovering has shown, its actual velocity would be only 268 miles in an entire second. Hence the marvellous discrepancies which have been observed in the results of experiments made to determine the velocity of electricity on long wires are explained.

In the nerve itself, therefore, the velocity of transmission may be supposed to be the less as its resistance is greater. Now, Weber has shown that animal tissues in general have a conductivity only one fifty-millionth of that of copper. And Radcliffe found that a single inch of the sciatic nerve of a frog measured 40,000 ohms; a resistance eight times that of the entire Atlantic cable. In experimenting to confirm the above law of velocity, Gaugain measured the time of transmission of the electric current through a cotton thread 1.65 metres long and found it to be eleven seconds. Two similar threads placed consecutively, thus forming a conductor twice as long, required forty-four seconds for the passage of the current; or four times as long. From these data the velocity in the short thread is at the rate of only 0.15 metre in one second; and in the long one only about half this rate, of course. Hence the fact that the energy of nerve moves at the rate of only 28 metres per second is really no proof that it is not electricity.

The higher functions of the nerve-cell, those connected with mental processes, is a field too vast to be entered at this time. The double telegraph line of nerve, motor and sensor in their effect, but, as Vulpian has proved, precisely alike in function, are the avenues of ingress and egress. Every sensory impression is received by the *thalami optici*; every motor stimulus is sent out from the *corpora striata*. In the acts denominated reflex, the action goes from the spinal cord and is automatic and unconscious. Should the impression ascend higher to the sensory ganglia, the action is now conscious though none the less automatic. Finally, should deliberation be required before acting, the message is sent to the hemispheres by the sensory ganglia and will operates to produce the act. Based on principles which can be established by investigation, a true psychology is coming into being, developed by Bain Maudsley, Spencer and others. A physiological classification of mental operations is being formed which uses the terms of metaphysical psychology, but in a more clearly defined sense. Emotion, in this new science, is the sensibility of the vesicular neurin to ideas. Memory, the registration of stimuli by nutrition. Reflection is the reflex action of the cells in their relation to the cerebral ganglia. Attention is the arrest of the transformation of energy for a moment. Ratiocination is the balancing of one energy against another. Will is the reaction of impressions outward. And so through the list.

Among the physical aspects of the mind-question, the problem of the quantitative changes which take place in the organism is a very curious and interesting one. That the energy of the brain comes from the food will be disputed by no one in these days. Hence, the brain must act like a machine and transform energy. There is then a purely physiological representation of mental action, concerned with forces which are known and measurable. The researches of Lombard long ago showed the concomitant heat of mental action. Recent researches are equally interesting, which show that mental operations are not instantaneous but require a distinct time for their performance. By accurate chronographic measurement, Hirsch has shown that an irritation on the head is answered by a signal with the hand only after one-seventh of a second; that a sound on the ear is indicated by the hand in one-sixth of a second; and that when light irritates the eye, one-fifth of a second elapses before the hand moves. The mechanism of such a process is the following: Suppose the sound "A" is heard by the ear. After a latent period it is translated to some nerve cells and hence to the brain. From the brain it goes to other cells, ganglion cells, and to other nerves, and then to the different muscles of the chest and larnx, and then follows the audible response "A." Now since this whole process requires only one-sixth of a second, the question arises, how much of it is psychical. To answer it, the experiment is repeated but with this difference, that the particular sound to be used is unknown to the experimenter. Before the sound can be repeated by him therefore, a distinct act of discrimination is required, and the time taken is longer. Calling the time in the first experiment a, and in the second b, the difference $b—a$ is the time required for two distinct actions: one, that of distinguishing the sound, and the other, that of willing the corresponding movement. If now it be agreed that only the sound "A" shall be responded to when called, these may be separated since no other sound being responded to the latter action is eliminated. If the time now required be called c, the difference $c—a$ represents the time required for forming a judgment, and $c—b$ the time required for a volition. In making these measurements, Donders used an instrument devised by him, called a noëmotachograph and also a modification of it called a noëmotachometer. By these instruments different points of the body can be irritated, different sounds can be produced, and different color or letters can be shown, all by the electric spark. By subtracting the simple physiological time from the time given in any experiment, the time necessary for recognition may be obtained. By an addition to the apparatus, a second stimulus may be made to follow the first, either on the same or on a different sense; thus enabling the time necessary for a simple thought to be determined. As a result of his experiments, Donders found that the value $b—a$ in the case of a simple dilemma was seventy-five thousandths of a second, this being the time required for recognition and subsequent volition. In the same way $c—a$ has been shown to be forty-thousandths of a second, being the time required for simple recognition; there is left thirty-five thousandths of a second as the time required for volition. Moreover, by independent measurement with the noëmotachometer, exactly the same time, one twenty-fifth of a second, is found necessary to enable a judgment to be formed about the priority of two impulses acting on the same sense. If they act on different senses, more time is necessary. So also more time is required to recognize a letter by seeing its form than by hearing its sound. A man of middle age then, thinking not so very quickly, requires one twenty-fifth of a second for a simple thought.

Another important fact concerning nervous action is that its amount may be measured by the quantity of blood consumed in its performance. Dr. Mosso of Turin has devised an apparatus called the Plethysmograph—drawings of which were exhibited at the London Apparatus Exhibition of 1876—designed for measuring the volume of an organ. The fore-arm, for example, being the organ to be experimented on, is placed in a cylinder of water and tightly enclosed. A rubber tube connects the interior of the cylinder with the recording apparatus. With the electric circuit by which the stimulus was applied to produce contraction, were two keys, one of which was a dummy. It was noticed that, after using the active key several times, producing varying current strengths, the curve sank as before on pressing down the inactive key. Since no real effect was produced, the result was caused solely by the imagination, blood passed from the body to the brain in the act. To test further the effect of mental action, Dr. Pagliani, whose arm was in the apparatus, was requested to multiply 267 by 8, mentally, and to make a sign when he had finished. The recorded curve showed very distinctly how much more blood the brain took to perform the operation. Hence the plethysmograph is capable of measuring the relative amount of mental power required by different persons to work out the same mental problem. Indeed Mr. Gaskell suggests the use of this instrument in the examination room, to find out, in addition to the amount of knowledge a man possesses, how much effort it causes him to produce any particular result of brain-work. Dr. Mosso relates that while the apparatus was set up in his room in Turin, a classical man came in to see him. He looked very contemptuously upon it and asked of what use it could be, saying that it couldn't do anybody any good. Dr. Mosso replied, "Well now, I can tell you by that whether you can read Greek as easily as you can Latin." As the classicist would not believe it, his own arm was put into the apparatus and he was given a Latin book to read. A very slight sinking of the curve was the result. The Latin book was then taken away and a Greek book was given him. This produced immediately, a much deeper curve. He had asserted before that it was quite as easy for him to read Greek as Latin and that there was no difficulty in doing either. Dr. Mosso, however, was able to show him that he was laboring under a delusion. Again, this apparatus is so sensitive as to be useful for ascertaining how much a person is dreaming. When Dr. Pagliani went to sleep in the apparatus, the effect upon the resulting curve was very marked indeed. He said afterward that he had been in a sound sleep and remembered nothing of what passed in the room—that he had been absolutely unconscious; and yet, every little movement in the room, such as the slamming of a door, the barking of a dog, and even the knocking down of a bit of glass, were all marked on the curves. Sometimes he moved his lips and gave other evidences that he was dreaming; they were all recorded on the curve, the amount of blood required for dreaming diminishing that in the extremities. The emotions too left a record. When only a student came into the room, little or no effect appeared in the curve. But when Professor Ludwig himself came in, the arteries in the arm of the person in the apparatus contracted quite as strongly as upon a very decided electrical stimulation.

In an address of the retiring President of this Association, delivered but a few years ago, I find this sentence: "Thought cannot be a physical force, because thought admits of no measure." In the light of the rapid advances lately made in investigating mental action, we see that in

two directions at least, in its rate of action and of its relative energy, we may already measure thought, as we measure any other form of energy, by the effects it produces.

Passing now to the consideration of the general question of the transformation of energy which is effected by living beings, attention may be called to one or two points in general physics, as bearing upon its solution. The great law of the dissipation of energy, as modified by Thomson from the statement of Clausius, is thus stated: "The entropy of the universe tends to zero." In other words, the energy of the universe available for transmulation is approaching extinction. This conclusion is based upon the fact that while every form of energy can be completely converted into heat, heat cannot be completely converted into other forms of energy, nor these into each other. Hence it arises that energy is being gradually dissipated as heat. Moreover, since transformation can only result when heat passes from a higher to a lower temperature, it follows that when that perfect equilibrium of temperaiure is reached toward which events are tending, there can be no other energy than heat; and this absolutely inconvertible, irrevocable. To apply this law to the present case, the muscle, for example, is a machine for transforming the energy of food into work. Since, consequently, this conversion is not complete, it follows that heat must appear as a necessary result of muscu lar action. The heat of animal life, consequently, is not heat especially provided; it is simply the heat which inevitably results from an incomplete conversion of energy.

Again, the form of chemical action thus far assumed by physiologists fo account for the energy of the living animal has been combustion. But the science of thermo-chemistry, as developed in late years by Berthelot and Thomsen, has proved, that direct union of chemical substances may not only not evolve heat, but may actually absorb it. It appears, too, that thermal changes accompany all forms of chemical change, those of decomposition and exchange as well as those of synthesis. The animal absorbs highly complex substances as food, capable of innumerable stages of retrogressive metamorphosis before elimination. In each of these stages heat is evolved, being the energy successively stored up by the plant when it repeated these stages in the inverse order.

Another point of interest has reference to the modern views of capillarity. In 1838, J. W. Draper showed that capillarity is an electrical phenomena. Quite recently, Lippmann has developed and extended this view and fully confirmed it. Whenever the free surface of a liquid, curved by capillary action, is electrified it changes its form; and conversely, when such a surface is made by mechanical means to change its form, an electromotive force is developed. Based upon this principle Lippmann constructed a capillary reversible engine and an extremely sensitive capillary electometer. The former, when a current of electricity was applied to it, developed mechanical work and ran as a motor. When turned by hand, it became an electromotor. In the animal organism there are it is true but a few free surfaces where this action can take place. But Gore has shown that the same phenomenon appears between two liquids in contact, their boundary being altered in character by electrification. Indeed, when we consider the production of electricity by osmose, and of heat and electricity both, by imbibition, both capillary phenomena, the wonder is not that so much energy is evolved by the organism, but that it is so little. If the physical and chemical changes which take place within the body took place without it, there would be an abundant evolution of energy. Can we doubt that these changes are the cause of the energy exhibited by the organism?

Thus far, when we have spoken of a living being, we have had reference to the organism as a whole, and this of a rather complex kind. In this view of the case, however, we find that biological microscopists do not agree with us. "The cell alone," says Küss, "is the essentially vital element." Says Beale,—"There is in living matter nothing which can be called a mechanism, nothing in which structure can be discerned. A little transparent colorless material is the seat of these marvellous powers or properties which the form, structure and function of the tissues and organs of all living things are determined." And again, "However much organisms and their tissues in their fully formed state may vary as regards the character, properties and composition of the formed material, all were first in the condition of clear, transparent, structureless, formless living matter." So Ranvier: "Cellular elements possess all the essential vital properties of the complete organism." And Allman, in his address as President of the British Association last year, is still more explicit. "Every living being," he says, "has protoplasm as the essential matter of every living element of its structure." "No one who contemplates this spontaneously moving matter can deny that it is alive. Liquid as it is, it is a living liquid; organless and structureless as it is, it manifests the essential phenomena of life." "Coextensive with the whole of the organic nature—every vital act being referable to some mode or property of protoplasm, it becomes to the biologist what the ether is to the physicist." From these quotations it would seem that even in the highest animal there is nothing living but protoplasm or germinal matter "transparent, colorless, and, as far as can be ascertained by examination with the highest powers of the microscope, perfectly structureless. It exhibits these same characters at every period of its existence." Neither the contractile tissue of the muscle, the axis-cylinder of the nerve, nor the secreting cell of the gland, is living, according to Beale. Hence it would be fair to draw the inference that no vital force should be required to explain the phenomena of the nonliving matter of the body, such as the contraction of the muscle or the function of the nerve. If this be conceded it is a great point gained; since the phenomenon of life becomes vastly simplified when we have to account for it only as exhibited in this one single form of living matter, protoplasm. In describing its properties, Allman includes this remarkable mobility, these spontaneous movements, and says, "They result from its proper irritability, its essential constitution as living matter. From the facts there is but one legitimate conclusion, that life is a property of protoplasm." Beale, however, will not allow that life is "a property" of protoplasm. "It cannot be a property of matter," he says, "because it is in all respects essentially different in its actions from all acknowledged properties of matter." But the properties of bodies are only the characters by which we differentiate them. Two bodies having the same properties would only be two portions of the same substance. Because life, therefore, is unlike other properties of matter, it by no means follows that it is not a property of matter. No dictum is more absolute in science than the one which predicates properties upon constitution. To say that this property exhibited by protoplasm, marvellous and even unique though it be, is not a natural result of the constitution of the matter itself, but is due to an unknown entity, a *tertium quid*, which inhabits and controls it, is opposed to all scientific analogy and experience. To the statement of the vitalist that there is no evidence that life is a property of matter, we may reply with emphasis that there is not the slightest proof that it is not.

Chemistry tells us that complexity of composition involves complexity of properties. The grand progress which Organic Chemistry has made in recent times has been owing to the distinct recognition of the influence of structure upon properties. Isomerism is one of its most significant developments. The number of possible insomers increases enormously with the complexity of the molecule. Granted that we now know several of the proteid group of substancs: how many thousand may there be yet to know? Bodies of such extreme complexity of constitution may well have an indefinite number of isomers. Not only does chemistry not say that there cannot be such a thing but she encourages the expectation that there will be yet found the precise proteid of which the changes of protoplasm are properties. The rapid march of recent organic synthesis makes it quite certain that every distinct chemical substance of the living body will ultimately be produced in the laboratory; and this from inorganic materials. Given only the exact constitution of a compound, and its synthesis follows. When, therefore, the chemist shall succeed in producing a mass constitutionally identical with protoplasmic albumin, there is every reason to expect that it will exhibit all the phenomena which characterize its life; and this equally whether protoplasm be a single substance or a mixture of several closely allied substances.

But here a word should be said concerning a remarkable physical condition assumed by matter in organ-

ized beings. Graham, in 1862, drew the sharp line which separates colloid from crystalloid matter. "His researches have required," says Maudsley, "a change in our conception of solid matter. Instead of the notion of inert impenetrable matter, we must substitute the idea of matter which in its colloidal state is penetrable, exhibits energy, and is widely susceptible to external agents. This sort of energy is not a result of chemical action, for colloids are singularly inert in all ordinary chemical relations, but is a result of its unknown molecular constitution; and the undoubted existence of colloidal energy in organic substances, which are usually considered inert and called dead, may well warrant the belief of its larger and more essential operation in organic matter in the state of instability of composition in which it is when under the condition of life. Such energy would then suffice to account for the simple uniform movements of the homogeneous substance of which the lowest animal consists, and the absence of any differentiation of structure is a sufficient reason for the absence of any localization of any function and of the general uniform reaction to local impressions." Graham himself says: "the colloidal state may be looked upon as the probable primary source of the force appearing in the phenomena of vitality." The colloidal condition of the dynamical state of matter; the crystalloidal the static. The former, which is the rule in the organic kingdom of nature, is the exception in the inorganic. Aluminum and ferric hydrates, silicic acid and a few other inorganic substances, exist in the colloid condition. From analogy there would seem to be but little doubt that the colloid state of these bodies differ from their crystalloid state merely in the size of the molecule. In other words opal, which is colloid silica, is a polymer of quartz. If this theory be true there can be no doubt of the vastly greater complexity of a colloidal proteid molecule than of a crystalloid one. Now it is a very significant fact, in this connection, that not a single organic colloid has ever been synthesized. Gelatin, which is one of the best examples of a colloid, has a comparatively simple structure. And, although Gibbs showed, many years ago, that gelatin was probably an amido-derivative of the sugar group, yet no inverse process has yet given us this substance. That matter in the crystalloid and colloid forms may be chemically identical, differing only in the size of its molecule, may be quite possible. But it is also possible that the difference may be a physical one. To produce the colloid state from the crystalloid is by no means beyond the power of science. We qualify our previous statement then only so far as to say that when the chemist produces a body in the colloidal form, having the identical constitution of protoplasm, there is every reason to believe that it will have the properties of protoplasm.

The important question now arises whether, since the protoplasm of animals is identical with that of vegetables, and the latter is the food of the former, any protoplasm whatever is vitalized by the animal as such. That this identity exists would seem satisfactorily established. Though the protoplasm of vegetables is enclosed within a cellulose bag, it is only a closely imprisoned rhizopod. In the Nitella, it shows all its characteristic irritability, and from Vaucheria it escapes to exhibit all its amœboid movements. Spores swim about by cilia or flagella, and the cell division of the one kingdom is the same as that of the other. In plants, however, protoplasm seems to be associated with chlorophyll, whose function was for a long time supposed to be to decompose carbon dioxide under the influence of sunlight. But Draper in 1843, showed that this decomposition took place before the chlorophyll was formed. Recent researches have shown that the function of chlorophyll is wholly protective. The assimilative power of the protoplasm reaches its maximum in the orange and yellow rays. Now Bert has shown that the absorption band in the chlorophyll spectrum is in the exact position of this maximum. Hence, Gautier believes that this substance acts as a regulator of plant respiration, the greater or less amount of luminous energy thus absorbed and transformed, being utilized by the protoplasm and stored up. Growth and cell-division, however, are independent of orange light, and hence of chlorophyll. In the higher plants, these functions are performed by a separate and deep-lying set of cells. But in the lower, the same cell discharges both functions, assimilation going on in it during the day, and growth chiefly at night. Sachs had already proved that the maximum growth of plants takes place just before daylight and the minimum in the afternoon. This retarding action of sunlight upon growth is as curious as it is unexpected. It now appears that in orange light plants assimilate—absorb carbon dioxide and evolve oxygen—but do not grow—are not heliotropic; while in blue light they are heliotropic but do not give off oxygen. Chlorophyll, however, is not confined to vegetables; infusoria, hydras, and certain planarian worms are green from the presence of this substance, and Geddes has shown that such animals, placed in the sunlight, give off a gas which is more than half oxygen. These cells, moreover, contain starch granules.

A still more striking evidence of this intimate relationship has been developed by Darwin, in his researches upon insectivorous plants. Not only do these plants possess a mechanism for capturing insects, but they secrete a gastric juice which digests them. Nägeli has shown the presence of pepsin in yeast cells, and attention has lately been called by Wurtz and others to the juice of the *Carica papaya* which contains a pepsin-like substance capable of peptonizing fibrin completely. Moreover, there is the closest similarity between diastase and ptyalin; and the milk of the cow-tree, recently examined by Boussingault and found to resemble cream closely in composition, shows the presence of an emulsifying agent in the vegetable kingdom analogous to pancreatin in the animal.

Another most curious proof of the indentity of animal and vegetable protoplasm has been given by Claude Bernard, who has shown that both are alike sensitive to the influence of anæsthetics. A sensitive plant exposed to ether no longer closed its leaflets when touched. Assimilation and growth, as well as germination, are arrested by chloroform. The yeast plant when etherized no longer decomposes sugar to produce alcohol and carbon dioxide; while the inversive and non-vital ferment still acts to convert the cane-sugar into glucose; precisely as under these circumstances, the diastasic ferment converts the starch of the seed into sugar. By arresting anæsthetically the process by which carbon dioxide is absorbed and oxygen evolved, the true respiratory process, being less effected, now appears; and Schutzenberger has proved that the fresh cells of the yeast plan breathe like an aquatic animal.

It would seem then that the protoplasmic life of animals is identical with that of plants; a certain measure of destructive metamorphosis taking place in each, evolving energy and producing carbon-dioxide and water. When, however, this function is examined quantitatively, its maximum is seen to be reached in the animal. While the assimilative function characterizes the plant, the destructive function distinguishes the animal. Hence it is the function of the plant to store up energy, to produce the highly complex protoplasm. This, consumed by the animal as his food, continues his existence as a living being, the energy gradually set free by its successive steps of retrogressive metamorphosis, appearing as the work which he performs. If this view be correct, it would follow that every individual substance found in the animal—save only those which result from degredation—must be found in the plant upon which it feeds, and this is the fact. The myosin which Kühne has shown to be the distinctive proteid of muscle, Vines has found in the aleuron grains of the lupine and the castor oil plant, along with vitellini the special proteid of the vitellus. The researches of Weyl & Bischoff have proved that gluten is formed in the dough of wheat flour by the action of a ferment upon the globulin-substance or plant-myosin which it contains, precisely as Hammarsten has shown fibrin is produced in the action of a similar ferment upon fibrinogen. Not only this; Hoppe Seyler has extracted from maize the identical substance which has been shown by Liebriech to be the essential chemical constituent of nerve tissue, protagon.

The evidence then would seem conclusive that, since the protoplasm of the animal and the vegetable kingdoms is identical, the former in all cases being derived from the latter, the animal as such neither produces nor vitalizes any protoplasm. Two inferences seem naturally to follow from this conclusion: 1st, that all the properties of animal protoplasm, and of the animal organism of which it constitutes the essential part, must have a previous existence in the

plant; 2d, that hence the solution of the life-question in the Myxomycetes will solve the life-problem for the highest vertebrate.

Another consideration which must not be left out of the account in any discussion of the life-question is the potent influence of environment. Ordinary examples of this influence pass before our eyes every day. Heat necessitates the germination of the seed, and light causes the plant to grow. Gravity obliges its root to grow downward and its stem to ascend. Certain sensations from without excite inevitably muscular contraction; and a ludicrous idea may provoke laughter in defiance of the will. Epidemic and epizootic diseases show the dependence of function upon external conditions, and the germ theory demonstrates the utter disproportionality of the cause to the effect. The remarkable similarity in the periodicity observed between sun-spots and the weather has been extended to include the appearance of locusts and the advent of the plague. Even the body politic feels its influence, Jevons having established a coincident periodicity for commercial crises.

The modern theory of energy, however, puts this influence in a still stronger light. As defined hitherto, energy is either motion or position; is kinetic or potential. Energy of position derives its value obviously from the fact that in virtue of attraction it may become energy of motion. But attraction implies action at a distance; and action at a distance implies that matter may act where it is not. This of course is impossible; and hence action at a distance, and with it attraction and potential energy, are disappearing from the language of science. But what conception is it which is taking its place? By what action does the sun hold our earth in its orbit? The answer is to be found in the properties of the ether which fills all space. The existence of this ether, the phenomena of light and electricity abundantly prove. While so tenuous that Astronomy has been taxed to prove that it exerts an appreciable resisttance upon the least of the celestial bodies, its elasticity is such that its transmits a compression with a well nigh infinite velocity. On the one hand, Thomson has determined its inferior limit, and finds that a cubic mile of it would weigh only one thousand-millionth of a pound; on the other, Herschel has calculated that, if an amount of it equal in weight to a cubic inch of air be enclosed in a cubic inch of space, its reaction outward would be upward of seventeen billions of pounds. Instead of being represented as is our air, by the pressure of a homogeneous atmosphere five miles in height, such a pressure would represent just such a homogeneous atmosphere five and a half billions of miles high, or about one-third the distance to the nearest fixed star! In Herschel's own words: "Do what we will, adopt what hypothesis we please, there is no escape in dealing with the phenomena of light, from these gigantic numbers, or from the conception of enormous physical force in perpetual exertion at every point throughout all the immensity of space."

Now, as Preston has suggested, if we regard this ether as a gas, defined by the kinetic theory that its molecules move in straight lines, but with an enormous length of free path, it is obvious that this ether may be clearly conceived of as the source of all the motions of ordinary matter. It is an enormous storehouse of energy, which is continually passing to and from ordinary matter, precisely as we know it to do in the case of radiant transmission. Before so simple a conception as this, both potential energy and action at a distance are easily given up. All energy is kinetic energy, the energy of motion. In a narrower sense, the energy of matter-motion is ordinary kinetic energy; the energy of ether-motion, which may become matter-motion, fills the conception of the older potential energy. Giving now to the ether its storehouse of tremendous power, and giving to it the ability to transfer this power to ordinary matter upon opportunity, and we have an environment compared with which the strongest steel is but the breath of the summer air. In presence of such an energy it is that we live and move. In the midst of such tremendous power do we act. Is it a wonder that out of such a reservoir the power by which we live should irresistibly rush into the organism and appear as the transmuted energy which we recognize in the phenomena of life? Truly, as Spinoza has put it, "Man thinks himself most free when he is most a slave."

Such now are some of the facts and fancies to be found in the science of to-day concerning the phenomena of life. Physiologically considered, life has no mysterious passages, no sacred precincts into which the unhallowed foot of science may not enter. Research has steadily diminished day by day the phenomena supposed vital. Physiology is daily assuming more and more the character of an applied science. Every action performed by the living body is sooner or later to be pronounced chemical or physical. And when the last vestige of the vital principle shall disappear, the word "Life," if it remain at all, will remain to us only to signify, as a collective term, the sum of the phenomena exhibited by an active organized or organic being.

I cannot close without speaking a single word in favor of a vigorous development in this country of physiological research. What has already been done among us has been well done. I have said with diffidence what I have said in this address, because I see around me those who have made these subjects the study of their lives, and who are far more competent to discuss them than I am. But the laborers in the field are all too few, and the reasons therefor are not far to seek. One of these undoubtedly is the high scientific attainment necessary to a successful prosecution of this kind of investigation. The physiological student must be a physicist, a chemist, an anatomist and a physiologist all at once. Again, the course of instruction of those who might fairly be expected to enter upon this work —the medical students of the country—is directed toward making them practitioners rather than investigators. In the third place the importance of physiological studies in connection with zoölogical research is only beginning in this country to receive the share of attention it deserves. I well remember the gratification I experienced in 1873 upon receiving a letter from Professor Louis Agassiz, asking me to give some lectures at Penikese upon physiological chemistry; a new departure for those times. In this view of the case it seems very appropriate that a new subsection of this Association should be just now in process of formation. We welcome warmly the body of men who form it, and we predict that from the new subsection of Anatomy and Physiology most valuable contributions will be received for our proceedings.

It is a beautiful conception of science which regards the energy which is manifested on the earth as having its origin in the sun. Pulsating awhile in the ether-molecules which fill the intervening space, this motion reaches our earth and communicates its tremor to the molecules of its matter. Instantly all starts into life. The winds move, the waters rise and fall, the lightnings flash and the thunders roll, all as subdivisions of this received power. The muscle of the fleeing animal transforms it in escaping from the hunter who seeks to use it for the purpose of his destruction. The wave that runs along that tiny nerve-thread to apprise us of danger transmutes it, and the return pulse that removes us from its presence is a portion of it. The groan of the weary, the shriek of the tortured, the voicéd agony of the babeless mother, all borrow their significance from the same source. The magnificence of the work of a Leonardo da Vinci or a Michael Angelo; the divine creations of a Beethovan or a Mozart; the immortal Principia of a Newton and the Méchanique Celeste of a Laplace—all had their existence at some point of time in oscillations of ether in the intersolar space. But all this energy is only a transitory possession. As the sunlight gilds the mountain top and then glances off again into space, so this energy touches upon and beautifies our earth and then speeds on its way. What other worlds it reaches and vivifies, we may never know. Beyond the veil of the seen, science may not penetrate. But religion, more hopeful, seeks there for the new heavens and the new earth, wherein shall be solved the problems of a higher life.

THE recent artificial production of the diamond is closely followed by an interesting synthesis, by M. de Schulten, resulting in the mineral analcine. On heating a solution of silicate of soda or caustic soda, in presence of an aluminous glass, to a temperature of 190° C. (374° F.) in a closed vessel, during forty-eight hours, small but very perfect transparent crystals, imbedded in gelatinous silica, were formed on the walls of the tube. They answer in every respect to the mineralogical characteristics of analcites.

THE REDUCTION OF CHLORIDE ORES.

For the benefit of those not familiar with the processes of reducing gold and silver ores, a brief explanation of what is meant by "free milling," an expression so often used by mining men, may not be out of place. In separating, by amalgamation, the precious metals from gangue or waste rock with which they are almost always associated, it is necessary to the success of the process to present the particles of gold or silver contained in the ore to the mercury with which they are to be alloyed, in such form that the latter can seize upon them readily. If these metals always occurred in nature in their pure metallic state, this would be a very easy matter. In free milling gold ores it is frequently only necessary to place the quicksilver beneath the stamps of the battery in which the ore is crushed, and upon an inclined copper plate over which the pulp is carried by water after it leaves the battery. The stamps, by reducing the rock to fine particles, release the minute scales and crystals of gold, which are readily taken up by the quicksilver, while the rock, for which the mercury has no affinity, is carried away as "tailings."

But silver rarely occurs in a native or pure metallic state. It is usually mixed with clorine, lead, iron, sulphur, manganese, copper, antimony and other base metals, and is found in the form of chloride of silver, argentiferous galena, in which the silver is in the form of a sulphide, and in many other compounds, for most of which quicksilver has no more affinity than it has for the common rock of the gangue. In most cases, therefore, if the silver ore was simply crushed and brought into contact with an amalgamating surface, little or none of the metal would be caught by the quicksilver and saved. Mercury has a strong affinity for metallic silver. stronger even than that of chloride, so that ff chloride of silver and quicksilver are brought together the mercury will seize the silver, forming an amalgam, and the chlorine which is released will escape as gas or unite with some other substance which presents itself and for which it has an affinity; but sulphur will not give up silver, with which it is chemically mixed, to mercury, unless the sulphur has first been driven off by fire. This process of converting chloride of silver into an amalgam is not an instantaneous one like the amalgamation of free gold, but requires several hours to be perfected, and it is hastened by the presence of other chemicals, such as sulphate of copper, sulphuric acid, and cyanide of potassium, the action of which it is unnecessary to explain here.

In order to reduce silver ores by amalgamation, it is necessary, as will be understood from the above explanation, to have the particles of metal either in a pure or chloritic state. When they are found in nature in either of these conditions they need no special treatment before being put into the mill, and the treatment of them is called "raw amalgamation." The process employed is to crush the ore to a fine pulp, and then transfer it to a large round iron tub, where it is agitated for several hours in hot water with quicksilver, some or all the chemicals I have named being added with common salt to promote the union of the mercury and the silver. If the silver in the ore is in the form of a sulphide, as it frequently is, and the amalgamation process of reduction is to be employed, the ores have to be roasted with common salt for several hours after they are crushed. Without explaining in full the chemical reactions, I may simply say that the heat volatilizes the sulphur mixed with the silver, and separates the salt into its constituents of chlorine and sodium, the first of which unites with the silver from which the sulphur has been driven off, and forms a chloride which is then ready for the amalgamating pan. The desulphurization and chlorination of an ore is an expensive process, and greatly increases the cost of reduction.

When such metals as lead, zinc, or copper are present in ores in large quantities, it is usually cheaper to reduce them by smelting, and by that process the lead and copper are generally saved and add to the value of the product. Almost any ore can be reduced by fire, if it is mixed in small proportions with other smelting ores. In large smelting establishments like those at Denver, Omaha, and Newark, N. J., where great varieties of ores are purchased, even free milling rock can be used to advantage; but the reduction of most free milling ores by fire, without mixture with others, would be ruinously expensive if not physically mpracticable.

ON CURRENTS PRODUCED BY FRICTION BETWEEN CONDUCTING SUBSTANCES AND ON A NEW FORM OF TELEPHONE RECEIVER.*

In a communication to the Royal Society of Edinburgh of date January 6, 1879, I showed that "electric currents were produced by the mere friction between conducting substances." The existence of these currents can be easily demonstrated either by a telephone or a Thomson's galvanometer. I have since found that these currents are, for all pairs of metals which I have yet tried, in the same direction as the thermo-electric current got by heating the junction of the same two metals. They are also approximately at least, stronger in proportion as the metals rubbed are far apart on the thermo-electric scale—the strongest current, as far as I have yet observed, being got by rubbing antimony and bismuth together. These observations clearly point to a thermo-electric origin for the currents; but it is possible that they may be due partly to the currents suggested by Sir William Thomson as the cause of friction, and partly, also, to contact force between films of air or oxide adhering to the surfaces of the metals.

Having ascertained that these friction-currents are of some strength and fairly constant, I proceeded to make several kinds of machines for producing currents on this principle. One of them consists of a cylinder of antimony, which can be rotated rapidly, while a plate of bismuth is pressed hard against it by a stiff spring. When this machine is included in the same circuit with a microphone and a Bell telephone, the current got from it is quite sufficient to serve for the transmission of musical sounds and also loud speaking. The transmitter, which I have found most serviceable in my experiments, is made by screwing two small cubes of gas-carbon to a violin, and placing between them a long stick of carbon pointed at both ends, the points being made to rest in conical holes in the carbon cubes. The looseness of the contact is regulated by a paper spring. This forms an excellent and handy transmitter for all kinds of musical sounds, and also serves very well for transmitting speech.

Seeing that friction between metals clearly produces a current, it seemed natural to inquire if the converse held good, that is, if a current from a battery sent across the junction of two metals affected the friction of the one upon the other. I have tested for this in a variety of ways, and the results obtained leave me in doubt whether to attribute them to variations in the friction, or to actual sticking porduced by fusion of the points of contact through which the current passes. The most noticable effect is produced when one of the rubbing bodies is a mere point, and the other a smooth surface of metal. This led me to make a modification of the loud speaking telephone of Mr. Edison, in order to get audible indications of changes of friction produced by the passing of a variable current. It consists of a cylinder of bismuth accurately turned and revolving on centres. The rubber-point is made of a sewing-needle with its point bent at right angles, and its other end attached to the centre of the mica disk of a phonograph mouthpiece. It is evident that this is only a loose contact, which can be perpetually changed. When this apparatus is included in the circuit with the violin-microphone and three or four Bunsen cells, the violin sounds, as was to be expected, are heard proceeding from the loose contact, even when the cylinder is not rotated. They are increased, however, in a remarkable degree by rotating the cylinder slowly, so much so that a tune played on the violin can, with proper care, be distinctly heard all over an ordinary room.

With regard to the explanation of this effect, it is evident that electrolysis can in no sense come into play, as is supposed to be the case in Edison's instrument. I am inclined to look for the explanation rather in the direction of the Trevelyan rocker, although the circumstances are considerably different in the two cases. In the rocker we have the heat passing from a mass of hot metal through two points of support to a cold block, whereas, in the other case, the heat is only intense at the points of contact, the rest of the metals being comparatively unaffected. The variations n the current produced by the transmitting microphone must

* Abstract of a paper read before the Royal Society of Edinburgh by James Blyth, M. A., F.R.S.E., on May 3, 1880.

cause corresponding variations in the heat at the point of contact of the needle with the cylinder, and this again produces a mechanical movement of the pressing point, as well as of the air surrounding it, sufficient to give forth sound-waves. If such be the case the effect should be different for different metals, those answering best which have the lowest thermal conductivity and also the lowest specific heat. That this is really so, is showing by substituting cylinders of other metals for the bismuth, all other things remaining the same. In this way I have compared lead, tin, iron, copper, carbon, and find that they all give forth the simple loose contact sound when the cylinder is stationary, but that it is only with bismuth that there is any very great intensification of the sound when the cylinder is rotated. Now, by consulting the appropriate tables I find that bismuth is a fraction lower than any other common metal in specific, while heat is much below them all, in thermal conductivity. This seems to bear out my explanation to a certain extent.

THE subject of a depraved taste in animals is an interesting one, which has not been studied as much perhaps as it might. In human beings it would seem to depend on ill-health of either body or mind, but in animals it would seem as if it might be present and the animal enjoy good health. One remarkable instance in an herbivorous animal we can vouch for. It occurred in a sheep that had been shipped on board one of the P. and O. steamers to help to supply the kitchen on board, but while fattening it developed an inordinate taste for tobacco, which it would eat in any quantity that was given to it. It did not much care for cigars, and altogether objected to burnt ends; but it would greedily devour the half-chewed quid of a sailor or a handful of roll tobacco. While chewing there was apparently no undue flow of saliva, and its taste was so peculiar that most of the passengers on board amused themselves by feeding it, to see for themselves if it were really so. As a consequence, though in fair condition, the cook was afraid to kill the sheep, believing that the mutton would have the flavor of tobacco. Another very remarkable case has just been communicated to us by Mr. Francis Goodlake: this time a flesh-eating animal in the shape of a kitten, about five months old, who shows a passionate fondness for salads. It eats no end of sliced cucumber dressed with vinegar, even when hot with cayenne pepper. After a little fencing it has eaten a piece of boiled beef with mustard. Its mother was at least once seen to eat a slice of cucumber which had salt, pepper and vinegar on it. The kitten is apparently in good health, and its extraordinary taste is not easily accounted for. Even supposing it once got a feed of salmon mayonaise, why should it now select to prefer the dressing to the fish?—*Nature.*

NATURAL ENEMIES OF THE TELEGRAPH.—There is, apparently, no apparatus so liable to be interfered with by what we may call natural causes as the electric telegraph. Fish gnaw and mollusks overweight the submarine conductors of the subterranean wires; while there is at least one instance of a frolicsome whale entangling himself in a deep sea cable, to its utter disorganization. It is stated that within the three years ending 1878, there have been sixty serious interruptions to telegraphic communication in Summatra, by elephants. In one instance, these sagacious animals, most likely fearing snares, destroyed a considerable portion of the line, hiding away the wires and insulators in a canebreak. Monkeys of all tribes and sizes, too, in that favored island, use the poles and wires as gymnasia, occasionally breaking them and carrying off the insulators; while the numerous tigers, bears and buffaloes on the track render the watching and repair of the line a duty of great danger. In Australia, where there are no wild animals to injure the wires, which are carried great distances overland, they are said to be frequently cut down by the scarcely less wild aborigines, who manufacture from them rings, armlets and other varieties of barbaric ornament It has been suggested as a means of protection in this case that the posts should be constructed of iron, when the battery could be used to astonish any native climbing them with felonious intent.—*Scientific American.*

PHYSICAL NOTES.

IN an article of great length, extending through the last three numbers of the *Annalen der Physik und Chemie*, which exhibits extraordinary scope of research and ingenuity, the learned Professor Quincke exhausts the subject of electrical expansion. The following results are drawn from his investigation:

1. Solid and liquid bodies alter their volume when they are acted upon, the same as Leyden jars, by electrical forces.

2. This change of volume is not the effect of heat, but is mostly an expansion; though it may also be a contraction, as in the case of the fatty oils.

3. No change of volume was observable in gases under the action of electrical forces. If such occurred it was smaller than $\frac{1}{30000000000}$ of the original volume.

4. There was an instantaneous change of volume in flint glass, but it took longer in German glass, which is a better conductor of electricity. By discharge of the coatings of spherical and tubular condensers, the glass resumes its original volume.

5. There is a simultaneous change of length and volume in tubular condensers.

6. The change of volume and length increases as the difference of potential in the coatings, and inversely as the thickness of the insulating substance of the condenser; and they are nearly proportional to the square of strength of potential and thickness.

7. Under otherwise equal conditions the expansion in volume and length differ according to the insulating substance of the condenser.

8. After the discharge of the coatings of the condensers, there is a residue, so to speak, of this change of volume, which is very small in the case of flint glass, but greater in German glass, and which seems to have some connection with the electrical polarization of the mass of the glass itself.

9. The change of mass and volume does not result from an electrical compression of the insulating substance.

10. In flint glass electrical expansion takes place equally in all directions, as in the expansions produced by increase of temperature, independent of the character and direction of the electrical forces.

11. Electrical change of length and volume takes place in glass nearly in the same way with increase of temperature, as the dialectric constants, or the electrical conductivity of the glass.

12. Action of electrical forces diminish the elasticity of flint glass, German glass, and caoutchouc, but increase that of mica and gutta percha.

13. The electrical piercing of glass and other substances is a result of the unequal electrical expansion of the insulator in different places.

14. By unequal electrical expansion solid and liquid substances are unequally dilated and become double refracting, as other similar substances do when heated.

15. Glass, when equally expanded, shows no electrical double refraction under electrical forces.

16. The relation of substances with positive and negative double refraction (to which Dr. Kerr first called attention), is explained by the way in which different substances change their exponents of refraction with their density and volume.

17. With a constant difference of potential in the coating of a condenser, after long charging, the electrical force varies in different layers of the insulative substance at the same time, or in the same place at different times.

M. BERTHELOT has recently made an apparatus for measuring the heat of combustion of gases by detonation, which consists essentially of a bomb suspended in a calorimeter.

MR. W. E. HIDDEN, the mineral collector, has discovered in Burke County, N. C., a new locality of Furgusonite. The mineral was chemically determined by Dr. J. Lawrence Smith.